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Dual Mode Bandpass Filter Using Fractal Structure Based on Circular Ring Resonator and Defected Ground Structure

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Abstract: *In this paper, a narrow band bandpass filters (BPF) using fractal structure and Defected Ground Structure (DGS) is introduced to eliminate the unwanted second harmonic. The centeral frequency and bandwidth of the filter is 1.52 GHz and 3.3%, respectively and used in Global Positioning System (GPS). At first, the bandpass filter is designed with two transmission zeros in passband using fractal structure to increase the selectivity and reduce the size of the ring resonator structure to 75%. The second harmonic is then removed by DGS structure.*

Keywords: *Dual Mode BPF, DGS, Fractal, Second Harmonic, Transmission Zero, Circular Resonator*

1. INTRODUCTION

Microstrip filters are the essential parts of the microwave systems and have an important role in communication systems such as satellite and mobile communications. Because of their small size and low weight, they can be easily integrated with electronic circuits. In recent years, one of the most important challenge in the circuit design is to increase miniaturization of circuits while maintaining the quality. Fractal structure was first introduced by Mandelbrot in 1975 [1]. Two important properties of this structure are space filling and self similarity that cause to decrease the size of the structure [1-3].

Dual mode microstrip filters are widely used in mobile communications such as GPS and cellular mobile communications[4-6]. Their narrow bandwidth is due to poor coupling in this structure. Using transmission zeros also increases the selectivity of the filter [7]. Also, DGS on the bottom layer of Printed Circuit Board (PCB) is used to create smaller structures [8-13] and remove unwanted harmonics.

In this paper, A narrow band bandpass fractal filter with transmission zeros around the band pass is presented to increase selectivity of the filter. The DGS is used as a low-pass filter to eliminate second harmonic. In section 2, the design of narrow band bandpass filters is explained using transmition zeros. A low-pass filter using dumbbell-shaped DGS structure is designed with high Sharpness Factor, in section 3. Finally, the bandpass filter without second harmonic is investigated.

2. THE DESIGN OF NARROW BAND BAND PASS FILTER BASED ON FRACTAL STRUCTURE

Fractal structures have been used for many applications in the design of antennas and Microwave filters. The most famous fractal structures in antennas and Microwave filters, are Minkowski and Sierpinski structures [1-3].

Fig.1 shows the bandpass filters resonator using the fractal structure. Similar to the square resonators that resonance occurs in the width of the λg / 4 at its first resonant mode[4], the circular resonator, resonate in a diameter of about $\lambda g / 2\pi r$ at its first mode [14].

Figure 1 show the bandpass filters resonator by fractal structure. As almost square resonators, resonant in the width of the λg / 4 in its first resonant mode[4] circular resonator, resonant with a diameter of about $\lambda g / 2\pi r$ in its first mode of their own [14].

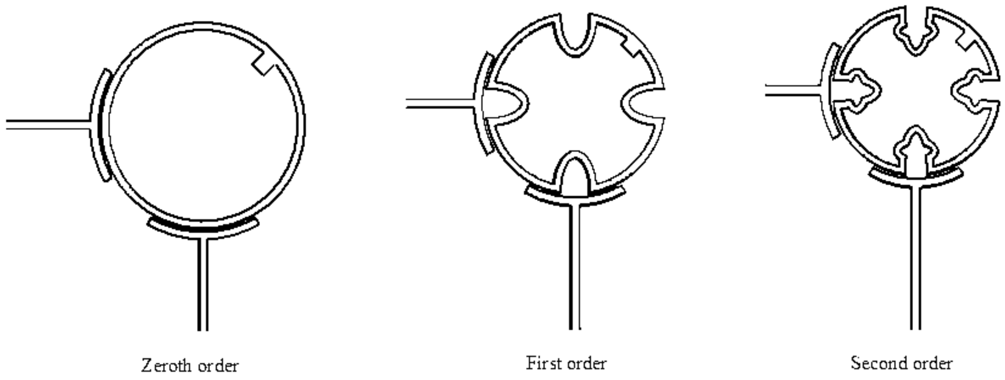

Fig1. *Bandpass filters using fractal structure*

In Fig. 1, an oval is used as a generator for the fractal circular resonator. Fractal structure shifts the frequency response of the filter to the left side due to the effect of space filling. Rectangular perturbation is added to circular patch with angle of 45 degree and in all cases the width of arms is 1mm.

The permittivity and thickness of substrate is chosen as 10.8 and 1.27 mm, respectively. So, the input and output impedance becomes 50 Ω. The other parameters of the structure are specified in Table 1.

Table1. *The dimensions of the three fractal filter in Fig. 1*

Filter order	Great circle diameter (mm)	distance of the arm to the patch (mm)	Perturbation(mm)
Zero order	24	0.25	2x2
First order	20	0.25	2x1
Second order	18	0.20	1.5x1.5

Fig. 2 shows the S parameters response for all three above filters. Changing the position of perturbation or changing its dimensions can displace of transmission zero or even degrade the filter response. In other words, transmission zero on imaginary axis of the S- plane can be moved to the real axis.

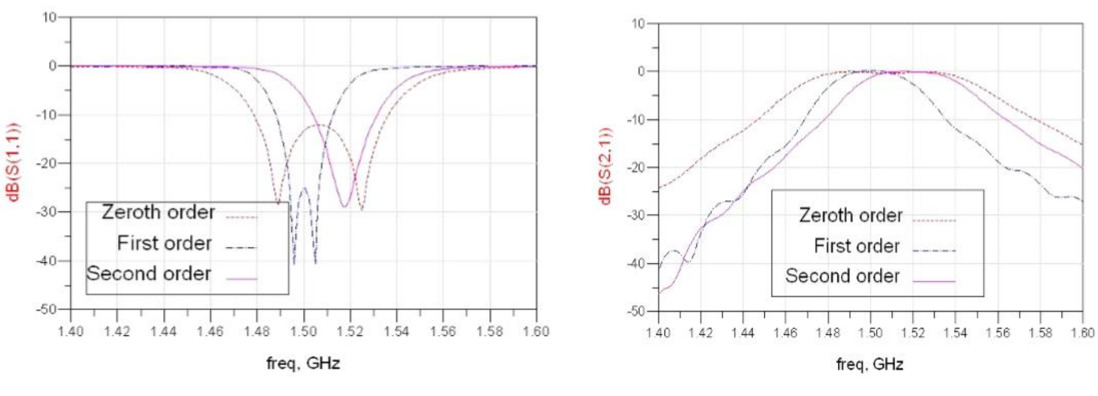

Fig2. *S parameters response for the filter in Fig.1*

3. The design of dumbbell shaped DGS low-pass filter with a high sharpness factor

The Equivalent circuit of a dumbbell shaped DGS filter is a parallel inductor and capacitor. The increase in the number of dumbbell DGS increases the number of parallel inductor and capacitor. Therefore, the order of low-pass filter will increase and the sharpness factor of filter will be improved [8-13].

Since the frequency response of filter before the second harmonic is desirable, we design a low-pass filter with a relatively high sharpness factor using dumbbell shaped DGS structure as shown in Fig. 3 to eliminate second harmonic and maintain the miniature filter. This DGS filter is simulated by CST software and the S-parameters of the structure are shown in Fig. 3. The sharpness factor is written as

$$\text{sharpness factor} = \frac{f_c}{f_0} \quad (1)$$

where fc and f0 are cut frequency and resonant frequency of S21 parameter, respectively. It is observed that fc and f0 in DGS filter are 2.099 GHz and 2.218 GHz, respectively. Also, the sharpness factor will be obtained as 0.946.

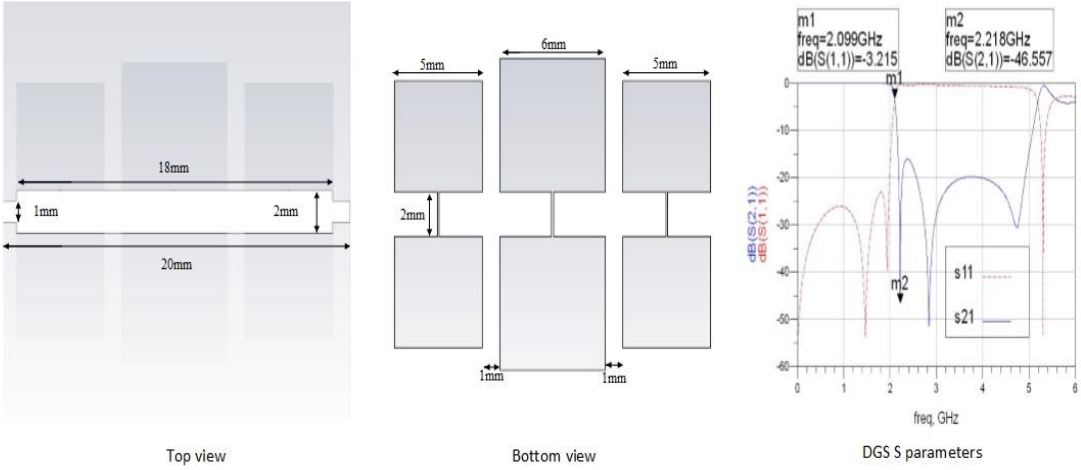

Fig3. *Low pass filter using DGS structure*

4. THE DESIGN OF NARROW BAND BANDPASS FILTER BY ELIMINATING THE SECOND HARMONIC

Combining the proposed bandpass filter in section 2 and the low pass DGS filter in section 3, a new bandpass filter is introduced as shown in Fig. 4. This Filter is miniature and eliminates the second harmonic efficiently. Frequency response of the proposed scheme is shown in Fig. 4. It is seen that the Central frequency and bandwidth of the filter are 1.52 GHz and 3.3%, respectively. The presence of the transmission zero around of pass band improved the quality of filter and the magnitude of S21 parameter in stop-band (from 0 to 1.45 GHz and from 1.60 to 3.75 GHz) is less than -20 dB.

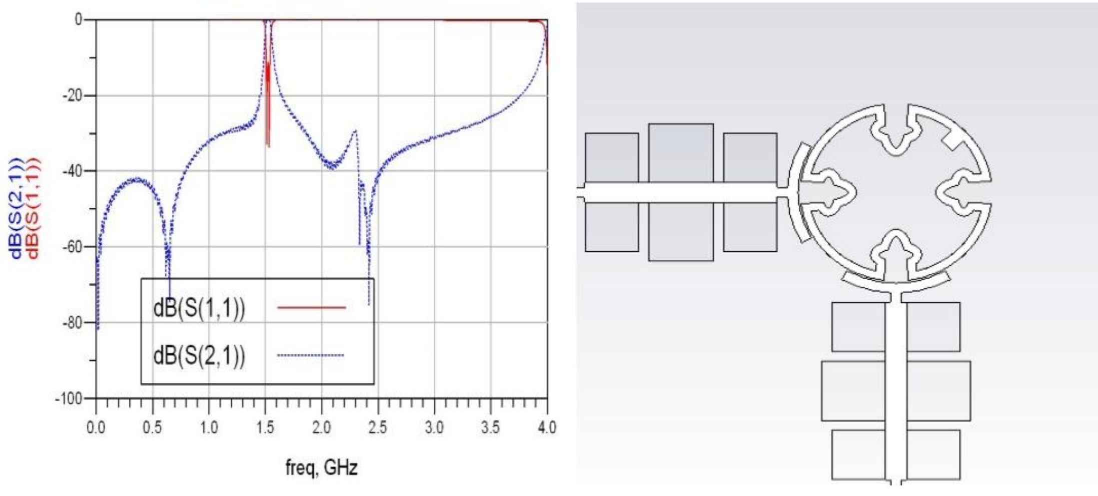

Fig4. *BPF with the removal of the second harmonic circuit and the frequency response*

5. DISCUSSION OF THE RESULTS

Because of using fractal structure, the diameter of circular filter reduces from 24 mm to 18 mm. So, the size of the filter drops to 75% of the size of the zero order and the smaller structure creates. If the dimensions of the perturbation or negative coupling value in Fig. 1 changes, the S parameter will not meet the filtering condition and the position of transmission zero in frequency response change.

Frequency response of the filter (Fig. 1) with 2mm x 2mm perturbation and 1.5mm x 1.5mm perturbation is shown in Fig. 5. As can be seen in Fig. 5, return loss is more than -10dB that is not suitable for this filter. Using three dumbbells in each arm improves the sharpness factor and the quality of filter. Comparing Figs. 4 and 5, it is obvious that the second harmonic reduces significantly.

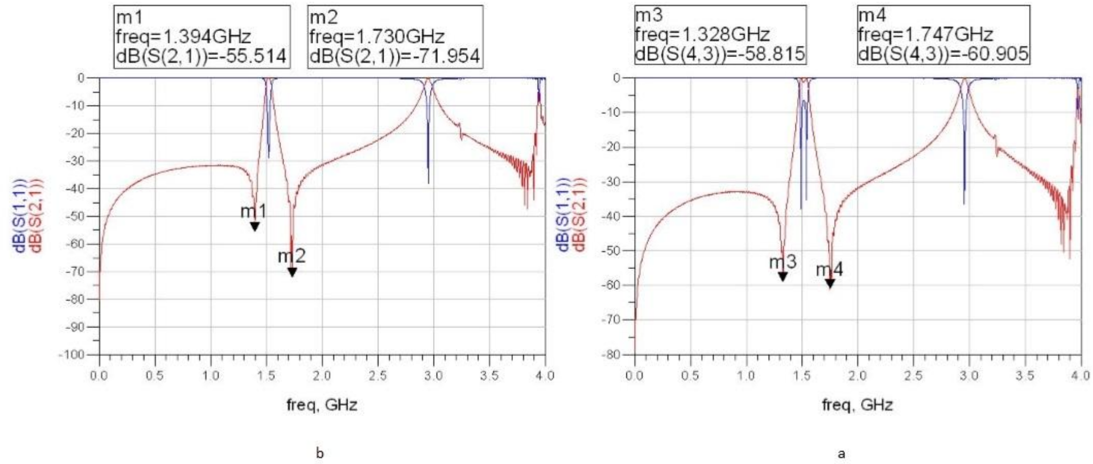

Fig5. *S- parameters for different dimensions of perturbation*

a)perturbation 2x2mm b)perturbation 1.5x1.5mm

Another important parameter in the design of the filter is the group delay. The flat group delay is desirable and large group delay causes distortion in the signal.

Fig. 6 shows the group delay of the filter is very small and is better than the elliptical filter in [7]. Due to relationship between insertion loss and group delay, the group delay and the quality factor of the filter will also increase near the transmission zero.

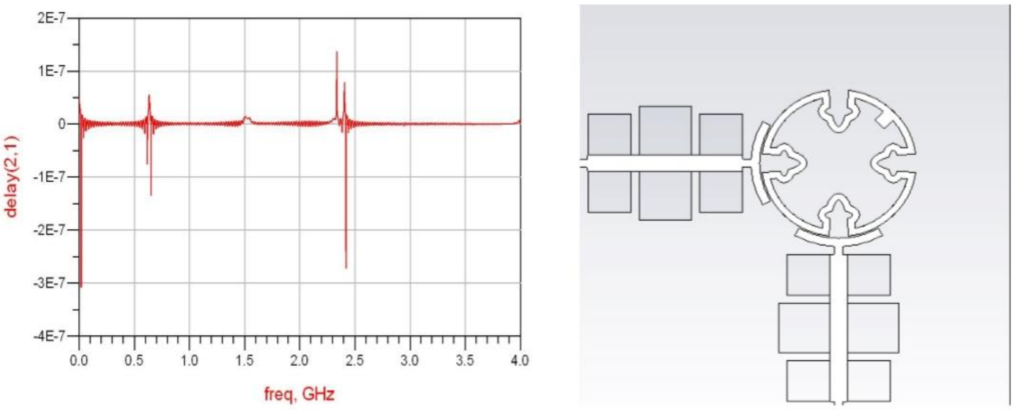

Fig6.*Group delay of bandpass filter with fractal and DGS structure*

6. Conclusion

In this paper, a simple fractal bandpass filter using DGS structure has been introduced. Fractal structure has been made the filter smaller due to space filling property and also improved the selectivity due to the transmission zeros in the frequency response of the filter. The DGS in the bottom layer of PCB has been removed the second harmonic due to high sharpness factor of low-pass DGS filter without changing the S-parameters and the size of the fractal filter.

References

[1] J. B. Pierre Jarry Design and Realizations of Miniaturized Fractal RF and Microwave Filters: A John Wiley & Sons, Inc, 2009.

[2] J. K. Ali, "A New Miniaturized Fractal Bandpass Filter Based On Dual-Mode Microstrip Square Ring Resonator," 5th International Multi-Conference on Systems, Signals and Devices, 2008.

[3] D.-S. L. Min-Hang Weng, Ru-Yuan Yang, Hung-Wei Wu, And Chia-Ling Liu, "A Sierpinski Fractal-Based Dual Mode Bandpass Filter," Microwave And Optical Technology Letters, Vol. 50, September 2008.

[4] S. S. Sholeh Jahani Maleki, Kambiz Sadat Naja, And Massoud Dousti, "A Novel Passive Dual-Band Bandpass Microwave Filter Using Microstrip Loop Resonators," Progress In Electromagnetic Research Symposium Proceedings,, Pp. 1407-1410, 27 March 2012.

[5] S. Amari, "Comments On “Description Of Coupling Between Degenerate Modes Of A Dual-Mode Microstrip Loop Resonator Using A Novel Perturbation Arrangement And Its Dual-Mode Bandpass Filter Applications”," IEEE Transactions On Microwave Theory And Techniques, Vol. 52, Pp. 2190-2192, September 2004.

[6] A. Görür, "Description Of Coupling Between Degenerate Modes Of A Dual-Mode Microstrip Loop Resonator Using A Novel Perturbation Arrangement And Its Dual-Mode Bandpass Filter Applications," IEEE Transactions On Microwave Theory And Techniques, Vol. 52, Pp. 671-677, February 2004.

[7] M. J. L. Jia-Sheng Hong, Microstrip Filters For Rf/Microwave Applications: John Wiley & Sons, Inc., 2001.

[8] A. K. V. Adel B. Abdel-Rahman, , Ahmed Boutejdar, And A. S. Omar, "Control Of Bandstop Response Of Hi–Lo Microstrip Low-Pass Filter Using Slot In Ground Plane," IEEE Transactions On Microwave Theory And Techniques, Vol. 52, Pp. 1008-1013, March 2004.

[9] J. M. A. M. V. K. Arjun Kumar, "A Comparative Study of Microstrip Bandstop Filters Loaded With Various Dumbbell-Shaped Defected Ground Structure (DGS)," International Journal of Microwave and Optical Technology, Vol. 8, Pp. 53-60, March 2013.

[10] Z.-F. L. Hai-Wen Liu, Xiao-Wei Sun and Jun-Fa Mao, "An Improved 1-D Periodic Defected Ground Structure for Microstrip Line," IEEE Microwave and Wireless Components Letters, Vol. 14, Pp. 180-182, April 2004.

[11] C.-S. K. Jong-Sik Lim, Young-Taek Lee, Dal Ahn And Sangwook Nam, "Design Of Lowpass Filters Using Defected Ground Structure And Compensated Microstrip Line," Electronics Letters, Vol. 38, Pp. 1357-1358, 24th October 2002.

[12] C.-S. K. Jong-Sik Lim, Dal Ahn, Yong-Chae Jeong, And Sangwook Nam, "Design Of Low-Pass Filters Using Defected Ground Structure," IEEE Transactions On Microwave Theory And Techniques, Vol. 53, Pp. 2539-2545, August 2005.

[13] Q. W. Yuchun Guo, "An Improved Parameters Extraction Method for Dumbbell-Shaped Defected Ground Structure," Scires, Pp. 197-200, 2010.

[14] K. C. A. L.-H. Hsieh, Microwave Ring Circuits and Related Structures: A John Wiley & Sons, Inc., 2004.

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